NRL Report 6334

Surface Chemical Methods of Displacing Water and/or Oils and Salvaging Flooded Equipment

Part 5 - Field Experience in Removing Sea-Water Salt Residues, Sand, Dust, and Soluble Corrosive Products from AN/FPS-16 (XN-1) Missile- and Satellite-Tracking Radar

H. R. Baker and P. B. Leach

Surface Chemistry Branch
Chemistry Division

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U.S. NAVAL RESEARCH LABORATORY
Washington, D.C.

Previous Reports in this Series

"Part 1 - Practical Applications," H.R. Baker, P.B. Leach, C.R. Singleterry, and W.A. Zisman, NRL Report 5606, Feb. 23, 1961

"Part 2 - Field Experience in Recovering Equipment Damaged by Fire Aboard USS CONSTELLATION and Equipment Subjected to Salt-Spray Acceptance Test," H.R. Baker, P.B. Leach, and C.R. Singleterry, NRL Report 5680, Sept. 19, 1961

"Part 3 - Field Experience in Recovering Equipment and Fuselage of HH 52A Helicopter After Submersion at Sea," H.R. Baker and P.B. Leach, NRL Report 6158, Oct. 19, 1964

"Part 4 - Aggressive Cleaner Formulations for Use on Corroded Equipment," H.R. Baker and P.B. Leach, NRL Report 6291, June 15, 1965

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ABSTRACT

Surface chemical techniques were previously developed at this Laboratory for the removal of oily and/or electrolyte contamination and the displacement of water from electrical and electronic equipment. Recently, these techniques were applied to the reconditioning of an AN/FPS-16(XN-1) radar which was badly contaminated with sea-water salt, sand, and dust after operation for several years near the beach at Patrick Air Force Base, Cape Kennedy, Florida. The method consisted of cleaning removable sections in an ultrasonic bath of emulsion cleaner, rinsing them with water, and spraying them with a water-displacing composition. Nondetachable parts were treated in a similar manner, except the emulsion cleaner was sprayed on. These methods proved to be successful in reconditioning the radar system, which consisted of the antenna and an extensive assembly of trailer-housed electronic gear and control console.

PROBLEM STATUS

This is an interim report; work on this problem is continuing.

AUTHORIZATION

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Manuscript submitted July 29, 1965.

SURFACE CHEMICAL METHODS OF DISPLACING WATER AND/OR OILS AND SALVAGING FLOODED EQUIPMENT

Part 5 - Field Experience in Removing Sea-Water Salt Residues, Sand, Dust, and Soluble Corrosive Products from AN/FPS-16(XN-1) Missile- and Satellite-Tracking Radar

INTRODUCTION

In recent years this Laboratory has developed a procedure for removing oily residues and/or sea water from equipment surfaces (1-10). This principle of displacing oils and water has reduced drying time on wet equipment from days to hours. Utilizing these features, a salvage or reconditioning system has been developed for the recovery of sea-water- or oil-contaminated equipment. This system (11) was used on a large scale to recondition electrical and electronic assemblies damaged by smoke, soot, sea water, and corrosive vapors during the fire on the aircraft carrier CONSTELLATION in December 1960 (5). A modification of this system has more recently been applied by the Coast Guard to the salvage of helicopters after submergence in the ocean (9). The recovery system is being used extensively by Government agencies and industry for routine cleaning of electronic equipment, teletypewriters, etc., to remove contamination by oily aerosols, dust, and spreading lubricants, as well as by sea-water salt residues. It utilizes ultrasonic agitation and/or spray washing as may be required by the complexity and the size of the apparatus.

This system has recently been applied to the reconditioning of an AN/FPS-16(XN-1) radar which was badly contaminated with sea-water salt, sand, and dust after operation for several years near the seashore at Patrick Air Force Base, Cape Kennedy, Florida. The contaminated radar was sent to Chesapeake Bay Division of the Naval Research Laboratory for reconditioning so that it could be used for further research studies in radar tracking. The radar consists of an antenna and trailer-housed console with supporting equipment, Fig. 1. The procedures used for cleaning are outlined in the following section of this report. More detailed instructions for the cleaning of the radar are provided in the Appendix.

RECONDITIONING PROCEDURE

Because the equipment to be cleaned was relatively free of oily contamination, the emulsion used in the first step of cleaning was made up of 20 vol-% cleaning concentrate and 80 vol-% water. Equipment that lent itself to cleaning in an ultrasonic bath and which was attached by military specification connectors was removed from both the antenna and trailer sections of the radar and cleaned in the ultrasonic cleaning tanks. Examples of the equipment cleaned ultrasonically are shown in Fig. 2.

All detachable equipment, after ultrasonic treatment in the cleaning emulsion, was rinsed in fresh water in an ultrasonic tank. Excess water was blown out with clean high-velocity air and the rinsed equipment sprayed with the water-displacing composition, Moisture Control for Electronics, Type II.* These items were allowed to partially dry at room temperatures and were then dried in an oven at 125 ± 5°F for about 16 hours.

*For composition, see the Appendix.

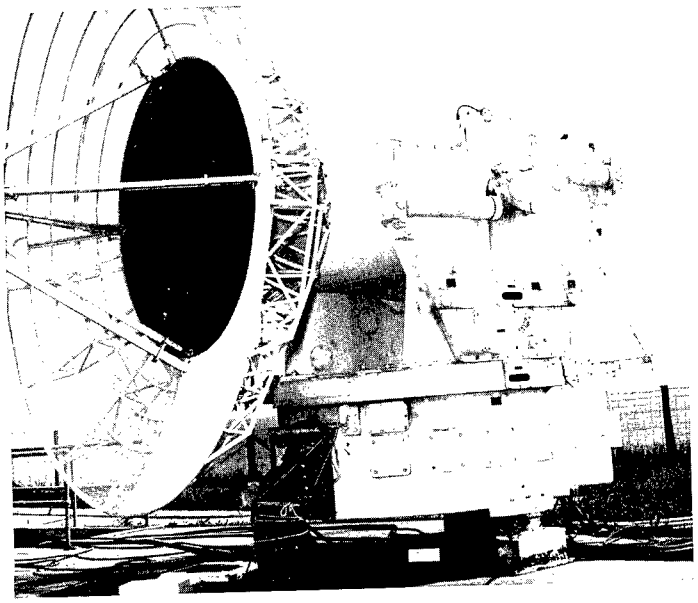

Fig. 1a - Antenna of AN/FPS-16(XN-1) radar

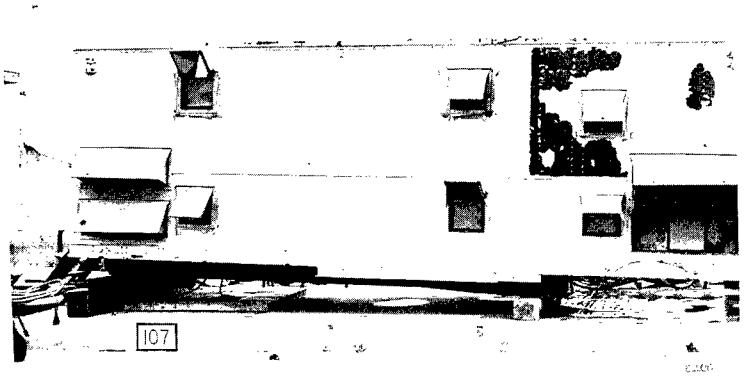

Fig. 1b - Trailer of AN/FPS-16(XN-1) radar

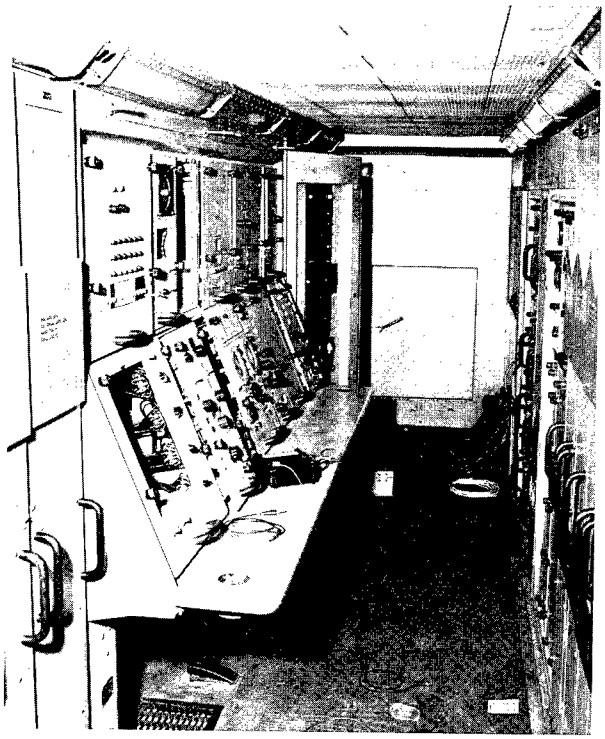

Fig. 1c - Interior of trailer of AN/FPS-16(XN-1) radar showing console and electronic gear racks

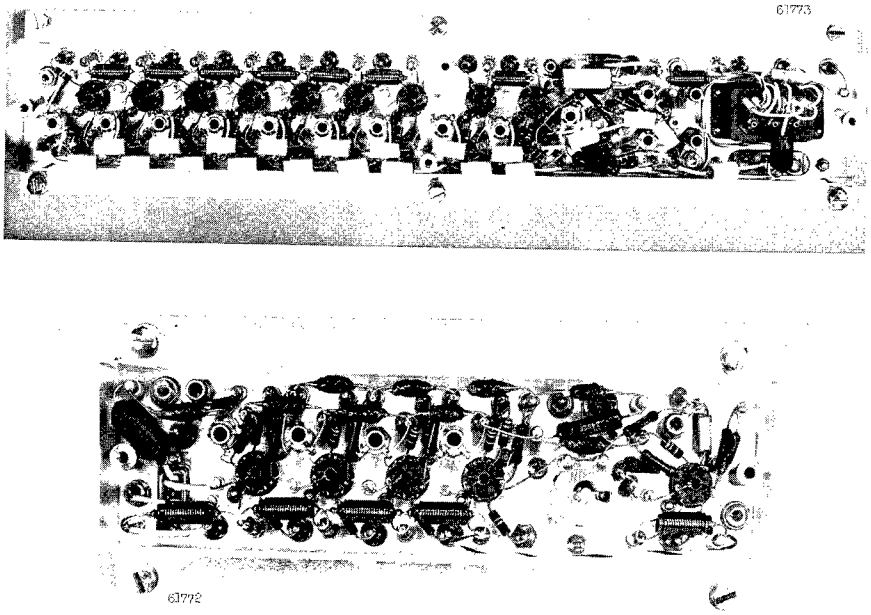

Fig. 2 - Typical electronic units of radar after ultrasonic cleaning

A conventional air-pressurized spray cleaning gun was used to spray-wash with the emulsion cleaner all surfaces, wiring, junction boxes, etc., of the antenna unit not amenable to ultrasonic cleaning, Fig. 3. After cleaning, all spray-washed surfaces were rinsed by flushing with fresh water, and the excess was blown off with clean high-velocity air. The equipment was then sprayed with water-displacing composition Moisture Control for Electronics, Type II, and dried by positioning the antenna to take advantage of solar radiation (temperature 90°F, R.H. 35%, and winds 8 to 10 knots). In case of inclement weather the antenna section could have been dried by the use of hot air blowers and/or dehumidifiers.

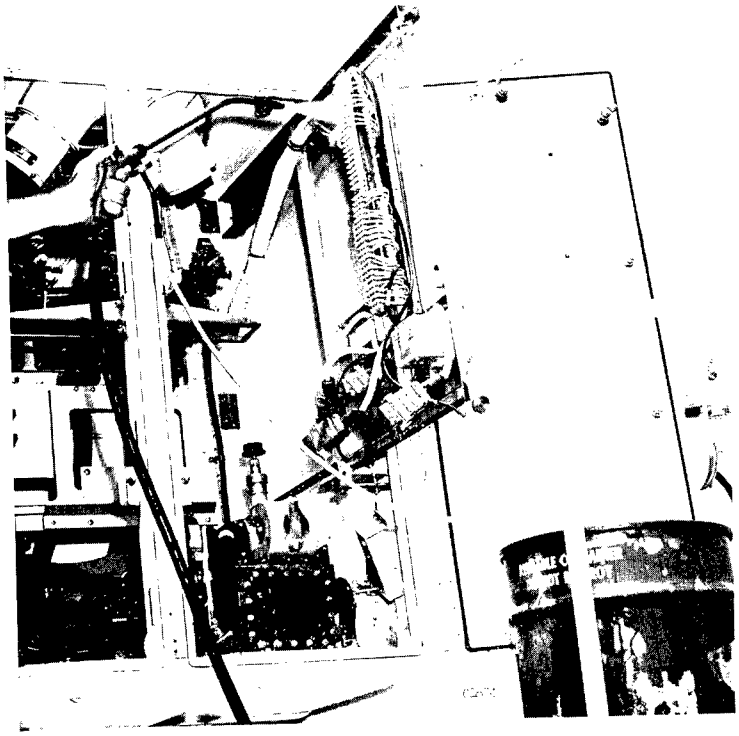

Fig. 3 - In situ spray cleaning of equipment not removed from antenna mount (note suction line from sprayer to large cleaning emulsion reservoir)

To make sure that all contaminating sea-water salt residues were removed from the cable connectors, the latter were cleaned by immersion in the cleaning emulsion in the ultrasonic tank, Fig. 4. To do this, the ultrasonic cleaning tank was moved to different locations inside the radar trailer and antenna unit so that the connectors would reach the tank without disassembly from the connecting electrical harness. They were then rinsed in fresh water in the ultrasonic tank, freed of excess water by blowing with clean high-velocity air, and sprayed with the water-displacing composition. The clean connectors were then allowed to dry in the summer heat.

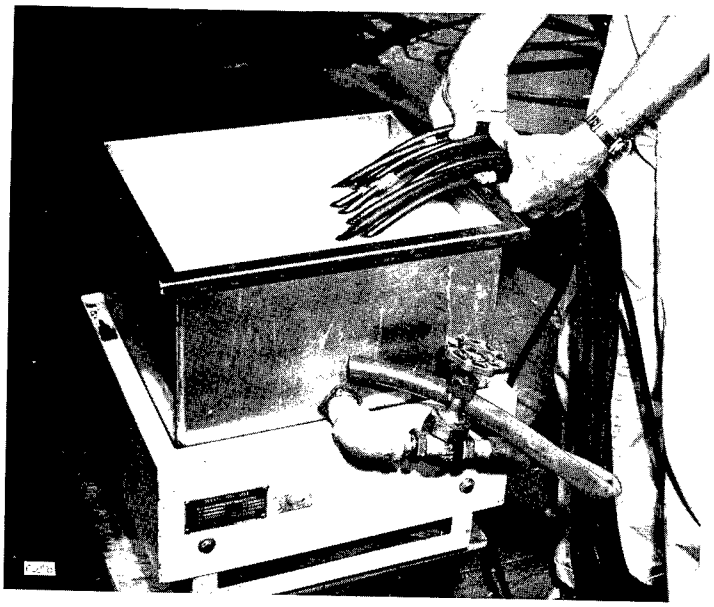

Fig. 4 - Cable connectors being cleaned in the ultrasonic tank

When the radar arrived at the Chesapeake Bay Division, the undercarriage of the trailer was removed and the trailer was set on timbers. In order to get adequate drainage when cleaning the nondetachable components of the trailer, the floor drain plugs were removed and the rear end was elevated about 8 in. The floor boards were removed in order to gain access to the wires and connectors beneath them. Adequate ventilation was obtained by opening the door and using a fan to exhaust vapors from the trailer during cleaning operations, Fig. 5. Figure 6 shows typical sections being cleaned in the trailer. The first attempt to dry the trailer equipment not removed for ultrasonic cleaning was made with a 5-ton mobile dehumidifier, but without auxiliary heating. After three days it could be seen that this treatment was not removing the moisture efficiently, so two 2000-watt heater-blowers were used for 8 hours during the day and the dehumidifier for 16 hours during the night. The average temperature in the trailer during the heating period was about 125°F. The heating and dehumidification cycle was continued for four days, until drying was complete.

The clean and dry subassemblies from the ultrasonic treatment were sent to the Tracking Branch of the NRL Radar Division, where they were subjected to electronic specification checkout. Any necessary repairs were made before the equipment was released for reinstallation in the radar.

EFFECT OF ULTRASONIC CLEANING ON ELECTRON TUBES OF THE FPS-16(XN-1) RADAR

An evaluation of electron tubes before and after ultrasonic cleaning was conducted at this Laboratory (12). There had been some questions concerning the survival rate of electron tubes which remain in the chassis and are subjected to the vibrations encountered in ultrasonic cleaning.

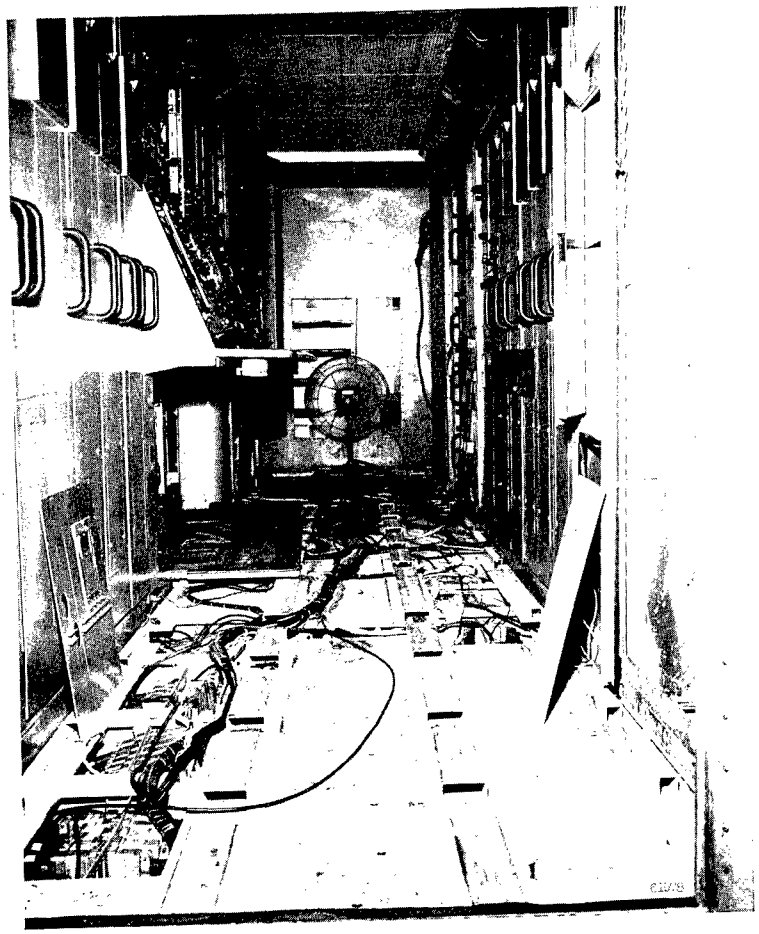

Fig. 5 - Radar trailer interior showing floor boards removed and fan ventilating system

A series of nine-pin miniature tubes from the reference driver unit of the radar were removed, and a careful measure was made of the dynamic mutual conductance of each. These tubes had been fired previously and had had considerable use in the FSP-16(XN-1) radar, so that some had deteriorated appreciably. Their mutual conductance ranged between poor and good. The tubes were then installed in their respective chassis and subjected to an ultrasonic signal of 20 kc at a power intensity of 10 watts/sq in. for about 8 minutes during the cleaning and rinsing cycles of the cleaning procedure. The tubes were then removed and their dynamic mutual conductance remeasured. The results of the measurements before and after cleaning are shown in Table 1. It can be seen from the table that the electron tubes underwent the ultrasonic cleaning process with negligible damage or deterioration in performance.

CONCLUSIONS AND RECOMMENDATIONS

1. Surface chemical cleaning procedures have been shown to be effective and profitable for routine maintenance of large and small electrical and electronic assemblies contaminated with sea-salt residues, dust, dirt, sand, lint, etc.

Table 1*
Evaluation of Electron Tubes Before and After Ultrasonic Cleaning

Tube No.	Tube Type	Mutual Conductance (micromhos)	
		Before Cleaning	After Cleaning
V3401	5814WA	2050 / 2800	2050 / 3000
V3402	5687WA	6700 / 6500	6800 / 6300
V3403	5814WA	250 (bad) / 1950 (weak)	250 (bad) / 1950 (weak)
V3404	5814WA	2600 / 2650	2700 / 2800
V3405	5670	4800 / 4500	4300 / 4200
V3406	5687WA	7200 / 6500	7000 / 6500
V3407	5687WA	4800 / 5000	5200 / 5800
V3408	5687	4200 / 3500	4200 / 3500

*Data supplied by James E. Lewis, Radar Tracking Branch, Radar Division, NRL (12).

2. The cleaning of the radar removed conducting sea-salt residues, thus practically eliminating liability to failure caused by conducting electrolytes within the radar system.

3. Electron tubes underwent the ultrasonic cleaning process with little or no damage or deterioration in performance.

4. The success encountered in this field application suggests that routine cleaning and maintenance of electronic equipment at periodic intervals should be instituted by many Government agencies. Such a practice would minimize failures caused by accumulating contaminants and thus reduce the overall cost of maintenance repairs.

ACKNOWLEDGMENTS

The authors acknowledge with pleasure the cooperation of N. V. O'Neal, J. E. Lewis, D. A. Halcombe, and M. T. Bufton of the Radar Division, and A. K. Bramlett, W. K. Fliss, P. A. Curran, and M. E. Thomas of the Applications Research Division of the Chesapeake Bay Division, NRL.

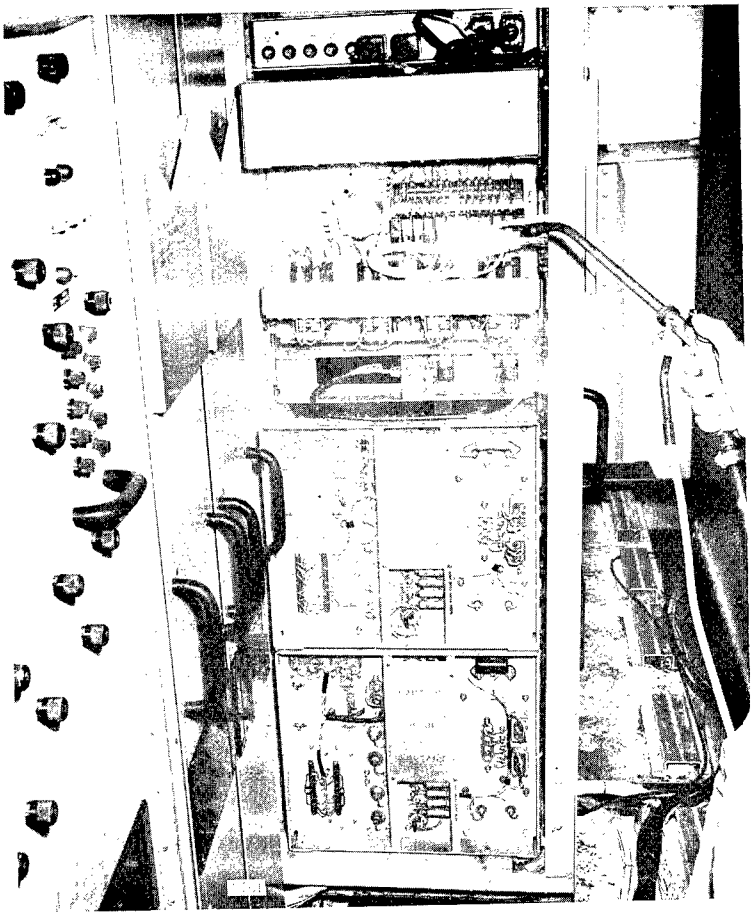

Fig. 6a - In situ spray cleaning of nondetachable equipment--high-voltage rack

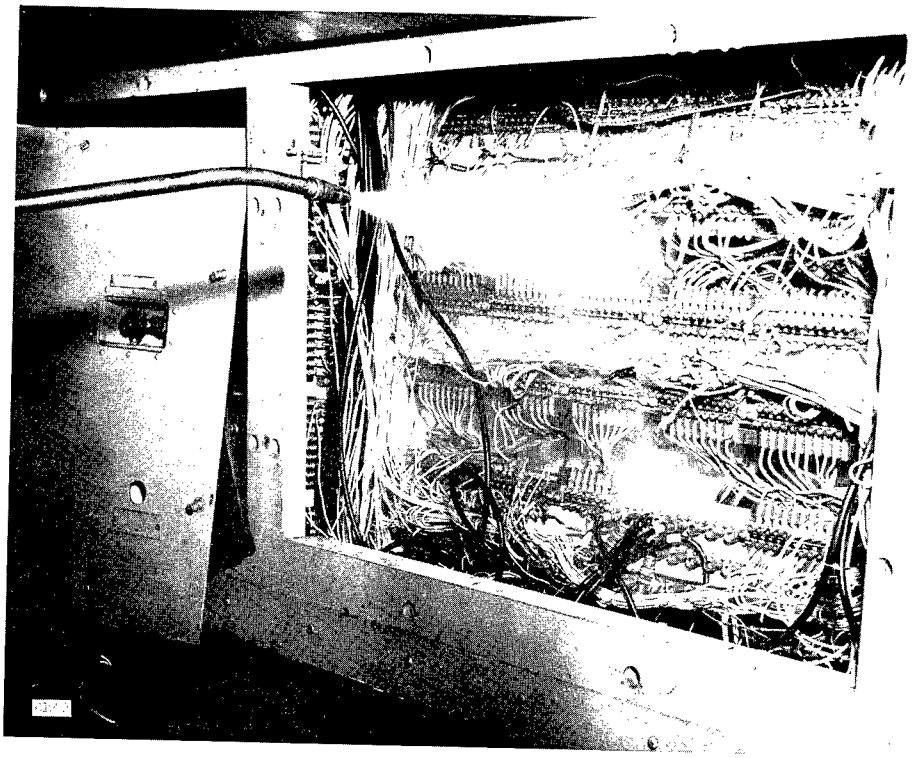

Fig. 6b - In situ spray cleaning of nondetachable equipment--console entry panel

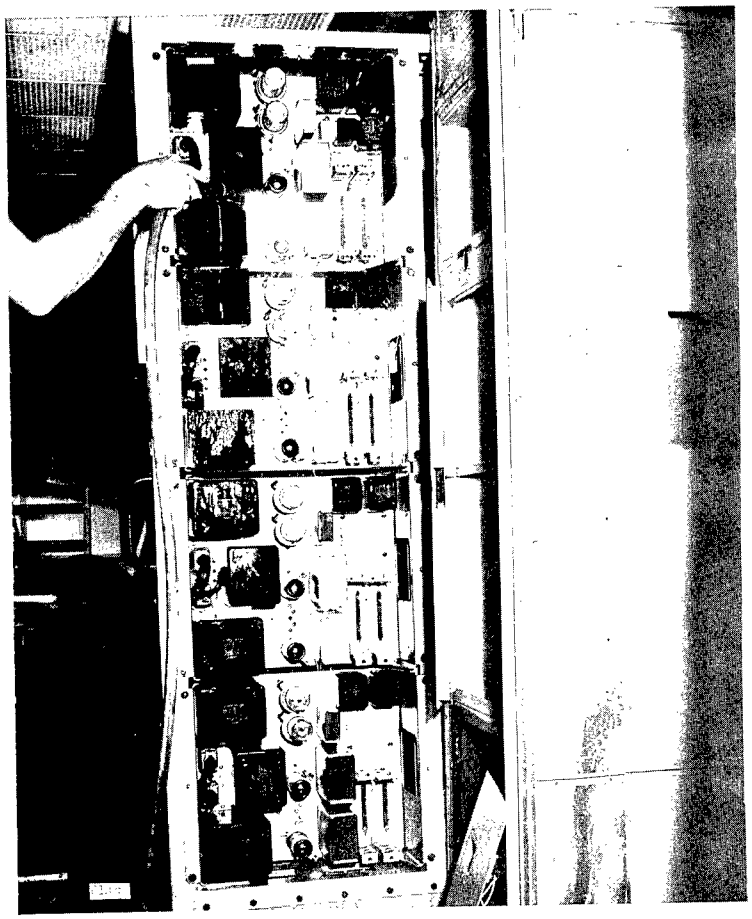

Fig. 6c - In situ spray cleaning of nondetachable equipment--power supply rack

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11. "Reconditioning of Flooded Equipment," U.S. Navy Bureau of Ships Technical Manual, NavShips 250-000, Chapter 9190, Section X

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APPENDIX

OUTLINE OF PROCEDURE AND FACILITIES FOR REMOVING SEA-WATER SALT RESIDUES, SAND, DUST, AND SOLUBLE CORROSIVE PRODUCTS FROM RADAR AND ASSOCIATED EQUIPMENT

RECONDITIONING PROCEDURE

1. Remove those electronic parts that lend themselves to ultrasonic cleaning (those which were attached by use of military specified connectors in both the antenna and trailer sections of the radar).

2. Remove sea-water salt residues, sand, dust, and soluble corrosive products from the detached components with emulsion cleaning composition in ultrasonic bath. (Pressure spray application or immersion in air-agitated tank may be substituted if circumstances require, but they are less efficient.)

3. Rinse in ultrasonic bath of fresh water to remove the emulsion cleaner. (Rinsing by fresh water spray or by immersion in an air-agitated tank of fresh water may be substituted for ultrasonic rinse but are less efficient for removal of emulsion cleaner.)

4. Spray-wash with the cleaning emulsion all surfaces, wiring, junction boxes, etc., not adaptable to ultrasonic cleaning and rinse with fresh-water spray.

5. Blow rinse water off equipment with clean air and follow with spray of water-displacing composition (Spra-Dri, Moisture Control for Electronics, Type II).

6. Dry in oven at 125 ± 5°F overnight. When an oven cannot be used, a portable hot air blower or dehumidifier may be substituted, or the equipment may be allowed to dry at summer temperatures for a longer time, providing the relative humidity is below 50%.

7. Electrical or electronic equipment should be checked for proper operation, defective components replaced, and adjustments made before returning to service.

EQUIPMENT AND CHEMICALS REQUIRED FOR CLEANING PROCEDURES

Equipment

1. Spray Equipment

a. Pressurized tap water or an auxiliary tank with a pump, and spray equipment to spray emulsion cleaner or fresh water.

b. A paint spray gun or other spraying equipment for applying bulk water-displacing composition in a fine mist. (If aerosol-pressurized water-displacing composition is used, the spray gun is not needed.)

2. Ultrasonic Cleaning Bath

An ultrasonic cleaning apparatus with a power rating of at least 5 watts/sq in. is required. The cleaning tanks must be large enough to accommodate the electronic equipment being cleaned. If ultrasonic equipment is not available, two tanks large enough to immerse any electronic equipment being cleaned should be provided for alternate use with air agitation. The ultrasonic cleaning tanks used at this Laboratory for cleaning and rinsing the electronic equipment were 16 in. wide, 20 in. long, and 18 in. deep.

3. Rinse and Storage Containers

Two to four tanks or containers, at least 16 in. in diameter and 20 in. deep, for storing fresh water and emulsion cleaning composition.

4. Clean Air Supply

Clean compressed air supply or high-velocity cold air blower for removal of rinse water.

5. Drying Equipment

A drying oven with temperature control or a portable hot air blower and/or a dehumidifier for final drying of cleaned equipment which cannot be put in an oven.

Chemicals

1. Water-Displacing Composition, Type II — This composition is commercially available in pressurized aerosol cans or in drums from the Spra-Dri Company, Division of Perfecting Service Company, Charlotte 6, N.C., under the designation Spra-Dri Moisture Control for Electronics, Type II. It is formulated as follows:

n-Butyl alcohol (1-butanol)	98.75 wt-%
2,6-Di-tert-butyl-4-methylphenol*	0.25 wt-%
Basic barium dinonylnaphthalene sulfonate† (50% inhibitor concentrate in volatile naphtha)	1.00 wt-%
	100.00 wt-%

2. Concentrate for Preparation of Emulsion Cleaner — This material has the following composition:

Dry cleaning solvent, Type II, Fed. Spec. P-S-661, Navy Stock No. W6850-285-8011 (55-gal drums), W6850-274-5421 (5-gal cans)	91 vol-%

*This is an oxidation inhibitor supplied under the trade name Parabar 441 and is available from Enjay Chemical Company, a division of Humble Oil and Refining Company, 15 West 51st Street, New York, N.Y.

†This is a rust inhibitor concentrate containing 50% inhibitor in naphtha solution. It is supplied under the trade name NA-SUL BSB by the R. T. Vanderbilt Company, Inc., 230 Park Avenue, New York, N.Y.

Diesel fuel oil, Type I, Mil. Spec. Mil-F-16884 Ships, Navy Stock No. WF9140-255-7764 (5-gal cans)	8 vol-%
Surfactant, nonionic	1 vol-%
	100 vol-%

Polyethylene glycol 400 monooleate, S1006, a product of Glyco Products Company, Inc., Empire State Building, New York, N.Y., is the surfactant recommended. However, Detergent, General Purpose, Mil. Spec. Mil-D-16791C-AN1-Type II, Navy Stock No. 7930-531-9716 (5-gal cans), can be used if the suggested surfactant is not available.

Immediately prior to use, 20 vol-% of the above concentrate is emulsified with 80 vol-% water. Up to 50 vol-% concentrate should be used if oily contamination is encountered.

3. Water Softener — The water used for preparing the emulsion cleaner should not have a hardness greater than 10 ppm. If it is harder than this, a water softener should be added as follows:

For a water hardness of 20 ppm, add 10 oz of water softener per 100 gal of water, and for a water hardness of 40 ppm, add 20 oz of water softener per 100 gal of water. The chemical compound designated as tetrasodium ethylenediaminetetraacetate dihydrate is recommended (see p. 13 of Ref. 9 for details). This compound is available commercially under several trade names, two of which are Sequestrene NA4 (supplied by Geigy Industrial Chemicals, Saw Mill River Road, Ardsley, New York) and Nullapon BF78 (a product of Antara Chemicals, 435 Hudson Street, New York, N.Y.).

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13. ABSTRACT

Surface chemical techniques were previously developed at this Laboratory for the removal of oily and/or electrolyte contamination and the displacement of water from electrical and electronic equipment. Recently, these techniques were applied to the reconditioning of an AN/FPS-16(XN-1) radar which was badly contaminated with sea-water salt, sand, and dust after operation for several years near the beach at Patrick Air Force Base, Cape Kennedy, Florida. The method consisted of cleaning removable sections in an ultrasonic bath of emulsion cleaner, rinsing them with a water-displacing composition. Nondetachable parts were treated in a similar manner, except the emulsion cleaner was sprayed on. These methods proved to be successful in reconditioning the radar system, which consisted of the antenna and an extensive assembly of trailer-housed electronic gear and control console.

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